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[No. 33.]

N. E. COTTON MANUFACTURERS' ASSOCIATION.

PROCEEDINGS

OF THE

SEMI-ANNUAL MEETING,

HELD AT BOSTON, OCTOBER 25, 1882.

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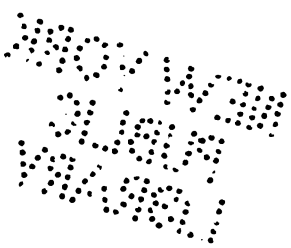

CALL FOR MEETING.

NEW ENGLAND COTTON MANUFACTURERS' ASSOCIATION,
BOSTON, Oct. 1, 1882.

DEAR SIR, — The stated semi-annual meeting of the Association will be held at the Massachusetts Institute of Technology, Boylston Street, Boston, on Wednesday, Oct. 25, 1882, at ten o'clock A.M., with an afternoon session beginning at two o'clock.

Topics heretofore discussed will still be in order if called up by any member; and, in addition, the Board have the pleasure to announce the following: —

ELISHA HARRIS, Esq., of Providence, R.I., by invitation of the Board, will present a paper descriptive of his NEW METHOD OF SPINNING COTTON AND OTHER TEXTILES BY THE HARRIS REVOLVING RING.

C. J. H. WOODBURY, Esq., of Boston, Mass., will present a communication upon the subject of ELECTRIC LIGHTING, AS RELATED TO COTTON MILLS. By invitation of the Board, EDWARD KILBURN, Esq., of New Bedford, Mass., CHARLES W. LIPPITT, Esq., of Woonsocket, R.I., and others, will be present, and participate in the discussion, giving accounts of their experience in the use of the electric light; and all members who have introduced the light into their mills are cordially urged to be present and report results.

A courteous invitation has been extended to the Association by the management of the New England Manufacturers' and Mechanics' Institute, to attend, in a body, the exhibition now in progress at their building on Huntington Avenue.

Members are reminded that, under the new By-laws, nominations to membership in the Association must be made in writing, at least one week before the date of meeting, and submitted to the Board of Government for recommendation.

The secretary will receive all nominations made not later than Oct. 18, and place them before the Board at its meeting on the morning of the 25th.

By order of the Board of Government.

AMBROSE EASTMAN,
Secretary.

PROCEEDINGS.

BOSTON, Wednesday, Oct. 25, 1882.

PURSUANT to the foregoing notice, the stated semi-annual meeting of the Association was this day held at the Massachusetts Institute of Technology, Oct. 25, 1882, at ten o'clock A.M. About one hundred and fifty members were present.

The President, Mr. JOHN KILBURN, occupied the chair, and called the meeting to order.

The PRESIDENT. The first business before the Association will be to hear the reading of the records of the last meeting. There being no objection, they will stand approved.

It was voted to omit the reading of the records of the previous meeting.

The PRESIDENT. Before commencing any other business, I will ask the Secretary to read a letter of invitation which he has received for the Association.

NEW ENGLAND MANUFACTURERS' AND MECHANICS' INSTITUTE.
TREASURER'S OFFICE, 38 Hawley Street,
BOSTON, Oct. 3, 1822.

AMBROSE EASTMAN, Esq., *Secretary of the New England Cotton Manufacturers' Association*, Sears Building, Boston.

Dear Sir, — The Management of the New England Exhibition Fair (now being held) would be very happy to have the members of the Association of which you are the Secretary visit our Exhibition Fair, in a body, upon the occasion of your next session the latter part of this month. The exhibits of electric lights, cotton, silk, woollen machinery, engines, boilers, etc., cannot, we think, but prove very interesting to your Association; and we hope the pleasure of your acceptance of this invitation.

Yours truly,

JOHN F. WOOD,
Treasurer and General Manager.

The PRESIDENT. What action will you take upon this letter addressed to the Secretary, inviting the Association to attend the exhibition in a body during this session? I suppose they

deserve some recognition, — either a vote of thanks in passing it by, or a vote accepting the invitation.

Mr. DANIELSON. So few of our members are present that I would suggest that you lay it upon the table for the present, and it will come up later in the meeting.

The PRESIDENT. I think the suggestion a very good one; and without asking for a vote I will lay it on the table, and we can take it up at a future time. The first business is the nomination of new members who have been recommended by the Board of Government.

The following, nominated in writing by members, and recommended by the Board of Government, were thereupon elected to membership: —

STEPHEN N. BOURNE	Manchester, N.H.
GEORGE A. CLARK	Manchester, N.H.
MELVILLE GAMBRILL	Wilmington, Del.
JOSEPH F. KNOWLES	New Bedford, Mass.
FRED C. MCDUFFIE	Lawrence, Mass.
TIMOTHY MERRICK	Holyoke, Mass.
ARNOLD B. SANFORD	Fall River, Mass.

The SECRETARY. I would state, Mr. President, that I have received applications from the following members to withdraw, as they are no longer engaged in the cotton manufacturing business: —

Messrs. WILLIAM AMORY, Jun. H. C. BOWEN.
CARLOS NUDD.

It was voted that they have leave to withdraw.

The PRESIDENT. The next thing in order will be to hear the article prepared by Mr. ELISHA HARRIS of Providence. He has, by invitation of the Board, been requested to present a paper descriptive of his new system of spinning cotton and other fibrous materials, by the Harris revolving ring spinning-frame.

Col. WEBBER. Mr. President, Mr. Harris requested me to read the paper for him. Preparatory to reading it I will call your attention to a little sketch which I have put up here to represent or illustrate what you already know, — the difference in the pull of the traveller when the bobbin is full, which is almost in the direction of the traveller on the ring, when it is pulling from the point of the bobbin. Mr. Harris's ring itself moves around the central bore described in his paper.

THE HARRIS REVOLVING RING.

It is well known that one of the most serious difficulties in ring spinning is the variable pull upon the traveller, caused by the difference in diameter of the full and empty bobbin; and this is especially noticeable in spinning weft or filling, when the diameter of the quill at the tip is not over three-sixteenths of an inch, while that of the base of the cone or the full bobbin is from an inch to an inch and one-eighth. This variation in diameter causes the line of draught on the traveller, which with the full bobbin forms nearly a tangent to the interior circle of the ring, to be nearly radial to it, with an empty one; and this increased drag upon the traveller not only causes frequent breakages in spinning, but also stretches the yarn, so that it is perceptibly finer when it is spun on the nose of the bobbin, than when it is spun on the bottom of the cone. Endeavors have been made to compensate for this difficulty by making a less draught at that period of the operation; but we believe the principle of curing one error by adding another to be wrong, and aim by our improvement to avoid the cause of the trouble, which we do by giving a revolving motion to the ring itself, in the same direction as that of the traveller, at a variable speed, so as to aid its slip, and reduce its friction on the ring.

This we accomplish by means of a shaft with whorls on it, located directly over the drum for driving the spindles, from which bands drive each ring separately, and attached by cross-girts to the ring-rail, and moving up and down with it.

This shaft is driven by a pair of conical drums from the main cylinder shaft, and is so arranged with a loose pulley on the large end of the receiving cone, as to remain stationary, when the wind is on or near the base of the bobbin, or nearly parallel to the path of the traveller.

When the cone of the bobbin begins to diminish to such a point as to materially increase the radial pull on the traveller, these conical drums are put in operation by a belt-shipper attached to the lift-motion, which moves the belt on to the cones, and gives a continually accelerated motion to the rings,

so that, when the wind reaches the tip of the bobbin, the rings will have their maximum speed of about three hundred revolutions per minute, or about one-twentieth the number of revolutions of the spindle at this point if the latter makes six thousand revolutions per minute; and this we find in actual practice to produce results which are highly satisfactory.

As the lift falls again, the belt is moved back on the cones, giving a retarding motion to the rings, until it reaches the point at which it began to operate, and is then either moved on to the loose pulley, and the rings remain stationary, or for very fine yarn are kept in motion at a slow speed.

We are often asked if this does not affect the twist; but answer that it does not in the least, as the relative speeds of the rolls and spindles remain the same; and the only thing that can be affected is the hardness of the wind upon the bobbin, and this is adjustable by the use of a heavier or lighter traveller according to the compactness of cop required.

We claim by means of this improvement the ability to use a much smaller quill or bobbin, and consequently holding as much yarn in a less outside diameter, enabling us to use a smaller ring, thus saving power both in the weight of bobbin to be carried and in the distance to be moved by the traveller; and we believe the power to be saved in this manner, and, by the diminution of the dead pull on the traveller when the wind is at the top of the bobbin, to be more than sufficient to give the necessary motion to the revolving rings. We are as yet unable to answer this question of power fully, as we have not yet tested a full-size frame; but we propose to do this in season to answer all questions at the next meeting of your Association.

The same invention is also applicable to warp spinning, by giving the ring a continuous accelerating and retarding motion, in which the maximum speed is given to the ring at the first start of the frame when the bobbin is empty, sufficient to diminish the strain on the yarn, and gradually reducing the motion at each traverse of the rail, as the bobbin is filled. But we claim the great advantage of our invention to be the capability of spinning any grade of yarn on the ring-frame that can be spun on the hand, or self-operating mule; and in proof of this we call your attention to the model frame now in operation at the fair of the New England Manufacturers' and Mechanics'

Institute, where we are spinning on a quill only five thirty-seconds of an inch in diameter at tip, and where we can show you samples of yarn from number eighty to number four hundred, spun on this frame from combed roving from the Willimantic Linen Company, which we believe has never before been accomplished on any ring-frame.

We invite you to examine this invention at the fair; and also call your attention to the adjustable roller-beam, by means of which the rolls can be adjusted at any desirable angle or pitch, so as to throw the twist more or less directly into the bite of the rolls according to the character of the yarn desired, or the quality of the stock used.

Finally, we claim by the use of this invention to be able to spin any fibrous material which can be drawn by draught-rolls, of any required degree of softness of twist, such as can be spun by any mule whatever; and to do this with the attention only of children of from twelve to fourteen years of age.

We also claim an increased production, owing to less breakage of ends, from the yarn not being overstrained in spinning, and an improvement in the quality of the yarn from the same cause, which will increase the production from the loom, and finally eradicate other objectionable features of the labor question, which so often disturb the peaceful harmony between labor and capital.

The PRESIDENT. I see Mr. Harris is present, and no doubt would be glad to answer any questions that any members may desire to ask in relation to his new method of spinning; or the subject is open for discussion in any of its varied forms. I might say to the gentlemen, that, in bringing this subject before you, it was remarked by one of the Board of Government that in doing this we should open the whole subject of spinning for further consideration; and if any gentleman has any thing to say on the subject, or any light to give on it, we should like to hear from him.

Mr. GOULDING. I should like to hear from the parties whether they have demonstrated whether it takes more or less power to spin the same number of yarn per hank.

Mr. HARRIS. It has not been demonstrated at present. I would like the opinion of Mr. Webber, so far as he can give it, from his judgment. He is acquainted with that subject, and

understands the workings of the new mode of spinning. I think he can give that answer more accurately than I could. It would be nothing more than an opinion.

Mr. WEBBER. As I stated, sir, and as Mr. Harris stated in his paper, the frame has not been actually tested; but careful observation of it shows that very little power is required to move the rings at that slow speed; and, as he says, the probability is (I think he is correct in it) that it will not require any more power to move the ring than will be saved in the friction of the ring upon the pull of the traveller when it is on the small point, and also in the weight which the bobbin has to carry. I thought at first that it would require considerable power to move the rings themselves in this way; but an examination of the model frame shows me that it requires very little, and I am quite inclined to agree with him that there will be no more power taken with him in this way than in the old way.

Mr. GOULDING. Mr. Webber, before you sit down, how about the lubrication of the ring?

Mr. WEBBER. This sketch which I made does not show that. Mr. Harris has some circulars here, which he will give you. The outer shell which I have drawn represents the movable part of the ring; and through that is an oil-hole filled with any bit of fibrous material, — sponge, woollen, or any thing else oiled may be put into that, and it oils itself gradually round the shell about which it moves. It rests merely on the small shoulder at the bottom, and it can be chamfered up at the bottom so as to make a continuous oil-chamber in there, in which it will move, and which will hold the oil, and keep it from flying out; but the oil is supposed to be fed through an oil-tube stuffed in that way. Mr. Harris's circulars will show that fully. Here is the ring itself, with the oil-passage.

The PRESIDENT. We shall be glad to hear from any one who desires to say any thing on the subject, or who desires to ask any questions of the inventor.

Mr. WEBBER. Mr. Harris also desires me to call your attention to samples which he has here. These in this largest box were spun from Egyptian stock, and these are spun from Willimantic cone roving from Sea Island stock.

Mr. HARRIS. They are both Egyptian and Sea Island stock.

The PRESIDENT. I would like to ask Mr. Harris if he claims

any advantage in the spinning of ordinary numbers of yarn by his method.

Mr. HARRIS. Yes, sir: from the very coarsest up to four hundred, as far as we have gone.

The PRESIDENT. By an increase of production, or by an increase of quality of yarn?

Mr. HARRIS. Both. We get quality at all hazard, and increase of production.

Mr. WEBBER. Mr. Harris desires me to say that all the numbers short of one hundred and eighty (from eighty to one hundred and eighty) are Egyptian stock. Those finer than one hundred and eighty are from Sea Island. Mr. Harris also desires me to say that the Egyptian stock was from the Conant Thread Company, and the others were spun from the Willimantic. He has here a little model, which you all understand very well, which serves to illustrate the difference in the pull, whether you are pulling tight against it or with the motion of the traveller.

Mr. GARSED. Mr. Chairman, with the view to start the discussion, and to bring out the talent on the subject, I want to ask Col. Webber, whether this machine which we see running so beautifully at the Institute, suppose it was made, as we frequently see ring frames, a little out of concentricity; suppose the ring to be out of its position at the bottom or top, — would it be any better, or do any better work, or any worse, than an ordidinary ring frame? I want to get the plain points down. You comprehend the question, colonel, do you?

Mr. WEBBER. I beg your pardon, Mr. Garsed.

Mr. GARSED. You comprehend the question?

Mr. WEBBER. I do not.

Mr. GARSED. I want to know, if the frame was made imperfectly, as we frequently see ring-frames, and we all know that the value of a ring-spindle comes from its accuracy of manufacture to a great extent, — I want to know from your standpoint, whether, if this machine is made inaccurate, as we often see them, would it do any better or any worse by this movable ring?

Mr. WEBBER. Decidedly better, sir. My impression is, it would obviate a great many of the difficulties of an imperfect ring-frame. I am glad you asked the question, because I omitted to state that in preparing the paper for Mr. Harris. If you had a perfect ring, you might be sure that your traveller would go

round without this; but in the imperfect, in ninety-nine cases out of a hundred, by giving the traveller a lift, and aiding its motion, it would be of greater advantage than it would be in a perfect one.

Mr. WILLSON. What did I understand the gentleman to say would be the maximum speed of the ring?

Mr. WEBBER. Mr. Harris proposes to bring the maximum speed of the ring to about three hundred revolutions a minute, and that is simply for the instant when the wind is on the very tip of the bobbin; and it will only dwell there for a second or a fraction of a second, and then the speed will again diminish as the wind falls down on the cone. And this motion of the ring, I should have also said, Mr. Harris has calculated very carefully. This increasing motion makes up for about the proportionate difference of the wind on the bobbin due to its two sizes.

Mr. WILLSON. The point to which I was leading was, whether it would have any other effect than simply to diminish the speed of the traveller to that extent. The speed of the traveller, we will suppose, is six thousand; the ring is going three hundred: it would be six thousand minus three hundred. Would it have any other effect than simply to diminish the speed of the traveller?

Mr. WEBBER. It has no effect on that, so that I do not understand Mr. Harris to claim that. It has no effect whatever except on the motion of the traveller. It does not affect the speed of the traveller. The traveller will go round the proper number to make the wind; but it will take off the dead pull, and allow the traveller to slip on the ring. The traveller will only get round as the spindle brings it, but it will be helped against that heavy choking pull when it is pulling square.

Mr. WILLSON. As six thousand to three hundred. If the ring is travelling at the rate of three hundred, and the traveller at six thousand, consequently it will be the same as though the traveller was travelling five thousand seven hundred: wouldn't it?

Mr. WEBBER. The traveller will make five thousand seven hundred revolutions round the point in the ring, but it will make the same proportionate number of revolutions to the spindle that it did before.

Mr. WILLSON. I understand that; but the point is, whether there is not just as much strain on the traveller as there would

be if you should diminish the speed of the traveller to five thousand seven hundred. I understand the twist to be the same; but whether after all it is not coming to exactly the same point that has been tried before on the travellers, to diminish the speed at that point of the traveller by a cone. I am not able yet to see that it is not.

Mr. WEBBER. I should say not, sir, because the motion of the ring gives the traveller a lift which prevents it from catching. It doesn't make any sort of odds about the number of revolutions it makes: it keeps it from stopping at any particular point; and the very fact that these numbers of yarn as fine as number four hundred have been spun on a ring-frame would tend to show that it has accomplished something which could not be done in the old way.

The PRESIDENT. If there is nothing further to be said on the subject of ring spinning, we will pass to the next business.

Mr. ATKINSON. Mr. President, as the members will go to the Fair to inspect this frame, I would suggest to them there are two little matters in connection with it that it may be worth their while to look for. One would be Mr. Wattles's spindle, which is near by.

The PRESIDENT. The subject of visiting the Fair has not yet been acted upon: it has been laid on the table.

Mr. ATKINSON. I merely wanted to call attention to this, and the anti-friction bearing upon which the cotton is subjected: an eighteen-hundred pound pulley is operated, without any lubricant, with a thread of Willimantic spool cotton.

The PRESIDENT. If there is nothing more to be said on the subject of ring spinning, we will pass to the next subject, that of electric lighting, upon which Mr. C. J. H. Woodbury will address the Association.

ELECTRIC LIGHTING IN MILLS.

BY C. J. H. WOODBURY.

ALTHOUGH the cruder forms of electric light were made early in this century, preceding the locomotive, the telegraph, and illuminating gas, yet the mechanical refinements devised within a few years have been necessary to master many of the practical and economic difficulties, and render it feasible to bring electric lighting from the laboratory to the commercial world, creating an element in manufacturing affairs.

Although our object is to consider electric lighting solely in regard to its employment for industrial purposes, a better understanding may be reached by examining some of the principles involved in its production.

The accumulation of electricity by means of a dynamo-machine is based upon two principles, — first, that, when a wire is moved across a magnet through the field of force, the power exerted against the attraction of the magnet is converted into electricity; second, when an electric current is passed through insulated wires coiled around a piece of iron, the iron is magnetized.

In a dynamo-machine the magnets are very feebly magnetized: but, when the armature is revolved, it generates an electric current which passes through the wires around the magnets, increasing their strength, and enabling them to produce a stronger current in the armature; and this in turn adds to the strength of the magnets, the armature and the magnets re-acting on each other until the limit of the capacity of the magnets is reached, after several hundred revolutions of the armature. When the motion of the armature is stopped, the magnets lose nearly all their magnetism, as soft iron will not retain magnetism like steel.

Permanent steel magnets were originally used for this purpose; but electro-magnets are capable of holding twenty times as much magnetism as permanent magnets.

This is the rough outline of dynamo-machines. Their con-

struction is not so simple a matter, involving numerous problems upon matters which cannot be considered here.

Electricity for lighting might be furnished by galvanic batteries, but the cost would amount to twenty-five times as much as when generated by a dynamo.

There are two methods of converting electricity into light. The arc light is chiefly due to the glowing of the tips of the carbons caused by the high temperature produced by the current overcoming the resistance offered by the space between the carbon poles, whereby the energy of the electricity is converted into heat. The carbons are slowly volatilized and partially burned. The intensely heated vapor adds to the illumination; but the combustion of the burning carbon interferes with the light, as the arc light is more brilliant when enclosed in a glass receiver and removing the air.

The incandescent light is produced by the current overcoming the resistance offered by a filament of carbon, and raising it to a temperature sufficient to render it luminous.

The immediate destruction of the carbon is prevented by regulating the quantity of the current, and enclosing the carbon in a glass bulb and exhausting the air, so that it cannot burn.

Both the arc and the incandescent light are due to the glowing of intensely heated carbon. In the arc light the incandescence is destructive to the carbon; and in the incandescent lamp the object is to make the carbon as enduring as possible under the conditions of brilliancy which are essential for satisfactory results. The arc lamps are placed at openings in the conducting wires, and the carbons form a portion of the circuit. The electricity passes through the lamps in order, and the tension is reduced a certain amount at each lamp.

In the incandescent system the lamps are hung in wires swung down from the main conductors, so that the current is divided, an equal portion passing through each lamp. The comparison is sometimes made, that the main conductors could be represented by the sides of a ladder, while the position of incandescent lamps would be in the middle of the rounds of the ladder.

In the arc light, where the carbon is heated to destruction, the total quantity of light for a given expenditure of electricity is about nine times what it is in an incandescent light working at a commercial rate. In an incandescent lamp the question

of endurance of the carbon is the second factor in determining the most advisable brilliancy for the light.

According to Howell's experiments on the Edison light, if the electricity supplied to a sixteen-candle power Edison lamp be increased one-fourth, the candle power is doubled, but the endurance of the lamp would be reduced.

The golden mean of the true economy between expense of renewals of lamps and that of power can be reached only by long experience.

I presume that the present intensity of brilliancy which has been adopted is at about the minimum cost for the present construction of carbons.

The unit of measurement of light is expressed in candle power, which is the light furnished by a standard wax candle burning one hundred and twenty grains per hour. The candle power of burning gas is the light given by an argand burner consuming five cubic feet of gas per hour.

With the incandescent lamp the light is nearly uniform in all directions.

In the arc light the terminals of the carbons are different; the lower carbon consuming to a sharp point, and the upper one is blunt and the end concave. The light emitted from these ends is not alike: the upper carbon having the most heated surface, about nine-tenths of the light is thrown downward below a horizontal plane. The power of arc lights, as generally stated, is that of the strongest rays which are thrown down at an angle of forty-five degrees, which is about twice the brilliancy of the average light. Nearly half of the light is held back by the white glass shades; and, the arc lights being farther apart, an excess of light is necessary to secure sufficient diffusion at extreme points, because the intensity of light diminishes as the square of the distance.

The value of electricity for lighting mills is based upon the character of the illumination desired; each mill being, to some extent, a law unto itself.

One of the first items of consideration is the influence of electric light upon the operative, considered as a machine to be kept in good condition in order to obtain the best results. As the electric light does not require any air to support combustion, it does not injure the air in a mill.

On the other hand, Dr. William A. Hammond states,[1] "A

[1] Our Continent, March 8, 1882.

gas-burner, consuming four cubic feet per hour, produces more carbonic-acid gas in a given time than is evolved from the respiration of eight adult human beings."

This is an important matter in night work, when the air becomes so impure that it prevents the operatives from doing the amount of work which they could do if the air were pure.

Gas-lights increase the temperature excessively. In the basement story of a mill four hundred by sixty-five feet, and fifteen feet high, were 456 looms on heavy colored cotton goods. The room was lighted by 457 four-foot gas-burners. When these were used it was stated that the temperature increased twenty-five degrees in an hour. Now the room is lighted by thirty-five electric lights, and the increase in temperature, if any, is not enough to be indicated by an ordinary thermometer. In two other mills the rise in temperature, after lighting the gas, varied from eleven to thirteen degrees in different rooms.

The economy of any light increases much more rapidly than the rise in temperature of the luminous body. A large gas-burner furnishes more light per foot of gas consumed than a small one.

[2]Nine years ago I made some experiments upon the efficiency of kerosene-burners, and obtained similar results; the largest burners of the same patterns showing the greatest economy.

The temperature of the upper carbon[3] in an electric arc light is estimated at six thousand degrees Fahrenheit, and the lower one at forty-five hundred degrees; but this estimate refers only to the special light experimented with, which used small carbons, and the general result to-day is probably greater than the one given above.

This high temperature furnishes much more light rays from a given amount of heat than a lower temperature would give.

Dr. Charles W. Siemens, in an address delivered before the British Association in Southampton, England, last August,[4] stated that in a gas-burner only one per cent of the calorific energy of combustion produced light; while, in the incandescent light, it was three and seven-tenths per cent; and in the arc light it amounted to thirty-three per cent. Whether subsequent investigation may not modify these results, is an open question; but the general statement that the electric light contains a much

[2] Journal Franklin Institute, August, 1873.
[3] Journal de Physique, August, 1879. [4] Engineering, Sept. 1, 1882.

smaller proportion of the heat rays than gas will be unquestioned.

It is stated by Mr. W. H. Pickering[5] that the injurious effects of artificial light upon the eyesight are due to heat from lights, and not to the light itself.

Another matter of value in electric lights is the ability to distinguish tints. The light from the tips of the carbons is white, and the light of the arc between them is a bluish purple: so that the general tint of the arc is that bluish white which has a very white appearance.

Where the use of shades of color is involved, electricity furnishes the only artificial light which can be feasibly used; and, in such cases where the operation of a certain department would otherwise be limited to the duration of sunlight, the economy from the use of the electric light is, to a certain extent, proportionate to extra profits accruing from this extension of the time of labor.

In other departments of manufacturing, the aid to the production of perfect work, by this improved illumination, is a source of additional revenue, because the proportion of damaged goods, usually made when the mill is badly lighted, is thereby diminished.

EXPENSE.

The cost of maintenance of a system of lighting bears little relation to its intrinsic worth. The item of cost of lighting is a small fraction of the whole operating expense; and what is desired is to light a mill so well that there will be no difference in the character of day and night work, either in quantity or quality. Any expenditure beyond that is unwarrantable.

The question of the cost of lighting by electricity is subject to many legitimate variations, of which the question of power is most variable. In a steam-mill, where the dynamo is driven by the same engine that runs the mill, it is generally charged with only its share of fuel; but not with any other expense of power, wherever it does not introduce any new expenditures in the way of plant, repairs, or labor in the engine-room.

In following this plan for the sake of uniformity, with other estimates of the cost of electric light, I do not wish to be con-

[5] Nature, Feb. 9, 1882.

sidered as indorsing this method of estimating. There is no reason why the electric apparatus should be supplied with power free of cost for transmission, interest, and supervision, which does not apply with equal force to every other machine in a mill, exempting it from these necessary items of cost. This paper refers only to the use of the electric light in mills, and not for circuit lighting, where the prime cost is much greater than in mills.

Some mills have departments which are only run by daylight, where work is thrown off at sundown, and so compensates for the power required by the dynamo. For example, in one mill using electric lights, the power used in the nepping-room is slightly more than is required for the dynamo: so, when the machinery in that room is stopped, the dynamo can be started without bringing any extra load on the engine. Most factories being driven by water power, with supplementary steam power during low water in the summer months, the electric lights would be required during the shorter days of the year at a time when there is usually an abundance of water; and the extra power can be used by the dynamo by the use of more water, without requiring any additional expense.

It is difficult to make a just comparison between various methods of illumination, because a change of light is always made an excuse for more light.

The majority of mills are lighted with gas made by the destructive distillation of petroleum, and of about eighty-candle power, which is generally reduced to sixty-candle power by mixing air with it, and burned through one-foot (nominal) burners, which consume about one and a quarter feet per hour, at the pressure generally used.

The annual cost of oil-gas per burner is from seventy-five cents to one dollar. In all these estimates, interest at six per cent forms one item in cost. One large corporation, with exceptional privileges, makes its coal-gas at an annual cost of sixty-nine cents per burner. Another corporation, inland, makes its coal-gas at $1.25 per thousand cubic feet, at an annual cost of $1.79 per burner, each burner consuming 1,433 cubic feet annually.

Of two large mills in the same city, manufacturing similar goods, the more modern one makes oil-gas at an annual cost of seventy-nine cents per burner, while the older one buys coal-gas at $2.65 per burner.

Sometimes, when the gas-making apparatus is not managed with skill, the goods are damaged from soot which settles on them.

The following shows the cost of lighting a woollen mill with high-test kerosene oil, including wicks, chimneys, and matches: —

YEAR.	Lamps Used.	Consumption of Oil.		Cost.	
		Gallons Total.	Gallons Per Lamp.	Total.	Per Lamp.
1877 . . .	125	167	1.33	$49.39	$0.40
1878 . . .	140	387	2.75	84.63	.61
1879 . . .	140	437	3.12	75.12	.54
1880 . . .	140	408	2.94	89.34	.64
1881 . . .	190	473	2.50	99 19	.52

The longer time light is required, the average cost is lessened, because, with the addition of operating expenses, the interest on plant, being a fixed amount, becomes a smaller proportion of the whole cost. In electric lighting, the cost of plant is so much that interest is an important item; and when a mill is run nights the relative cost of electric lighting is materially diminished. A white cotton mill, running sixty hours a week, generally uses light three hundred to three hundred and fifty hours a year; where they run sixty-six hours a week, lights are required four hundred to four hundred and fifty hours a year.

A dark mill requires about twice the number of lights that is sufficient in a white mill, and uses light about a hundred hours a year more than a white mill.

An arc light, as generally used in mills, requires about one-horse power. Mr. James Renfrew, jun., at Adams, Mass., has found, by test, that the forty-light Brush dynamos in his mills each require 36.6-horse power. The lights were running in a satisfactory manner, but no photometric tests were made.

The cost of arc lights in several steam-mills, running four hundred hours per year, is 6½ cents per hour; of which one cent and a half is for carbons, and five cents for attendance, coal, depreciation, and interest. When a mill runs nights, the hourly cost is diminished.

The ratio of substituting electric lights for gas is quite variable, being one arc light to from ten to twenty gas-burners. In one mill lighted by kerosene the ratio was one arc lamp to eight kerosene lamps.

In a colored mill one arc light will light the looms on seven hundred to fourteen hundred square feet of floor; but in a white mill the same light will be sufficient for looms on a thousand to two thousand square feet of floor.

The reflected light from white walls and ceilings adds very materially to the diffusion. A card-room forty-eight by a hundred feet, containing sixty-four cards, was satisfactorily lighted by one arc light. The end of the room was extended about forty feet; and the light was not satisfactory toward that end of the room, where the light was formerly ample, because the removal of the end wall took away what served as a reflector.

It is advisable to place the conducting wires of lighting systems so that the different circuits will light similarly shadowed portions of the mill; one circuit reaching the darker places, another lighter parts, so that each of the various dynamo-machines can be used at their full capacity, as the total light in the mill is being increased or diminished.

It is convenient to compare the cost of electric lighting with the expense of gas in the same place; although it must be remembered that gas does not furnish as much or as good light, and is therefore not so valuable where quantity or quality of light is of importance.

In a weave-room, on very fine work, twenty-four arc lights replaced 292 six-foot burners, which consume (292×6) 1,752 feet per hour, so one arc light represents the consumption of ($1{,}752 \div 24$) seventy-three feet of gas per hour. A careful estimate shows these arc lights to be costing 6½ cents an hour: so this arc lighting system represents gas at eighty-nine cents per thousand. A similar estimate in another mill gives the annual cost of gas $2,188, and electricity at $1,125, or equal to gas at ninety cents a thousand. The annual saving to that mill in lighting expenses by the use of electricity makes a profit of $1,063, which represents six per cent on $17,716, without making mention of any improvement in work or production due to that light. In both of these establishments the lights were used a[illegible]ar estimates give the cost of

sixty-five cents upward per thousand. In the case of incandescent lighting, the cost is more difficult to estimate, because they are run at all degrees of brilliancy, affecting both the power and the life of the lamp.

The duration of the carbon filament is the uncertain factor in estimating the cost of incandescent lighting. I do not know of any instance where all the incandescent lamps have become worn out by the ordinary use to which they are subjected, so as to reach an average of their ultimate duration.

The application of incandescent lighting is new, and the minimum guaranty of both companies may be considered as representing two years' ordinary use in a mill; and my experience in the matter has shown that this is largely exceeded.

The following records give the data of the longest time that I have at hand of the use of incandescent lamps: yet they are far from satisfactory, because they do not represent the average life of the carbons; because they are not all broken, no true average can yet be given.

Both the Edison and the Maxim lamps are guaranteed to average six hundred hours; yet in the New York post-office the average record of the Maxim lamps is stated to be 2,200 hours up to Nov. 28, and four lamps had already burned 4,820 hours.

The ferry-boat " Jersey City," belonging to the Pennsylvania Railroad, is lighted by the Maxim lights. I have a copy of the official record of these lamps, dated Aug. 29, 1882, showing that at that time the average was 1,609 hours.

The data for the above were taken with lamps in use, and do not represent their ultimate endurance.

Mr. Timothy Merrick of Holyoke authorizes me to give the facts respecting his experience with the Edison system in the Merrick Thread Company's mill No. 3. This mill runs all night, five nights in the week, for fifty-one weeks per year, using light 2,869 hours per annum. It was lighted by ninety-five burners with city gas, costing $2.13 net, which amounted to $225 per month. Ninety-five Edison B lamps (eight-candle power) were substituted for the gas. In the first thousand hours five lamp carbons had broken; and Oct. 20 they had been in use 1,278 hours, and eleven had broken.

Allowing that the lamps average six months' use, the annual cost of lighting is made up as follows: —

Two renewals of 95 lamps equals 190 lamps at $1.00	$190 00
Interest and depreciation	153 50
Six-horse power at $10	60 00
Annual cost Edison light	$403 50
Monthly cost Edison light	33 62
Monthly cost gas	225 00

The results from these lamps are very satisfactory, and certainly in excess of what would have been obtained if the lamps had been forced beyond their normal capacity.

The Holyoke Water Power Company furnish water power very cheaply; and the result may be interesting if we hold the Edison Company to their minimum guaranty, and also charge the dynamo with four pounds of coal per hourly horse power.

$4\frac{78}{100}$ renewals of 95 lamps equals 454 lamps at $1.00	$454 00
Interest and depreciation	153 50
$30\frac{74}{100}$ tons coal at $5.75	176 81
Annual cost Edison light	$784 31
Monthly cost Edison light	65 36

Which is equal to gas at sixty-five cents per thousand.

The mill is situated at the base of a high bank, and is only eleven feet six inches between floors, so it is very hot in summer; and Mr. Merrick informed me that it would have been impossible to run the mill nights during the extremely hot season last summer, if the help had been subjected to the heat and vitiated air from the burning gas.

It must be kept in mind that an instance of a mill running day and night is an extreme one in favor of the electric lights; but the data are given, and the matter can be estimated to suit other times of operation.

If these electric plants were charged the proportionate cost of power, besides coal, the cost would be estimated greater than stated above.

IMPROVEMENTS.

The question is frequently asked, Will there not be improvements in electric apparatus, so that the light will be furnished for less cost and power? Of course there will be improvements, but it seems as if they would refer to attachments rather than the more permanent portion of the apparatus. The dynamo-machines are the most perfect instruments used in the mechanic

arts, as they convert from eighty to over ninety per cent of the motive power into electricity delivered at the conducting wires. It will be found essential that all dynamos have current governors which regulate the supply of electricity in proportion to the demand, without waste of energy.

There does not seem to be any demand for a change in the system of wiring, in addition to what is now required by the insurance interests.

In the arc lamps there is urgent need of better carbons, and in the incandescent lamp there is a demand for the highest qualities of endurance and electrical resistance.

These are all matters of detail, and, except the first, refer to portions which are subject to continual renewal.

The so-called "storage" of electricity is a subject which is the object of much interest. Electricity alone, of all forms of energy, is used from hand to mouth, so that the dynamo must be equal to the greatest demand upon the system at any one instant.

All forms of electric lights require uniformity in the speed of the dynamo; and the incandescent lights are especially sensitive to variations in the speed, so that it is frequently advisable to have a separate engine solely on that account. Such uniform speed would not be essential for the dynamo used in charging secondary batteries.

In a storage battery the electricity is not accumulated in any manner, as is sometimes assumed; but a certain chemical action is produced by passing an electric current through the battery, and later on a counter-chemical action produces electricity when the battery is discharged.

The Faure storage battery consists of perforated sheets of lead, coated with red lead and covered with parchment paper and wrapped in woollen cloth. The whole is enclosed in a box, and covered with dilute sulphuric acid. On passing an electric current through the battery, the red lead on the negative side loses its oxygen, which combines with the red lead on the positive side; the result being that one coating of red lead is reduced to pure lead, and the other side changed to peroxide of lead. When the battery is put in use, the theory is that this atom of oxygen leaves the peroxide of lead on one side, and rejoins the spongy lead on the other side, producing the secondary current; but difficulty has been expe-

rienced from losses due to various kinds of local action in the battery, such as the deposition of sulphate of lead, and the injury to the sheets of felt, so that the electricity regained has not been as much as is desired.

Some of the electricity lost in the battery is expended in dissociating the water into its component parts, oxygen and hydrogen; but most of the electricity used in producing local action is expended in injuring the battery: so there is a depreciation due to this cause, in addition to the loss of electricity in the battery, which is the difference between the charging and discharging current.

Nevertheless, for domestic uses and the many places where a small motor for operating a dynamo is attended with so much trouble and expense, it would be far better to supply the electricity from secondary batteries, which have been charged where there are ample facilities for doing it in the most advantageous manner.

There are several forms of secondary batteries, all of which are similar in principle; and one free from the faults due to local action would be a great boon to all users of incandescent lamps, for then the apparatus would be permanent, and its efficiency such that would insure commercial success.

EXPERIENCE WITH ELECTRIC LIGHT IN MILLS.

THE general opinion of a great number using electric light in a practical way is of more weight than the conclusions of any single investigator.

In the pursuance of my occupation as inspector, it has been my duty to examine nearly every textile mill and many other establishments in New England, New York, New Jersey, and Pennsylvania, where electric lights are used.

I do not recall a single instance where the *quality* of the light was unsatisfactory.

A few extracts from my correspondence on the subject will show how it is regarded by those who deal with electric light solely in regard to its merits in practical application.

As none of these letters were written for publication, I do not feel authorized to give the names of the various writers; but all are either the executive or financial heads of mills insured in the mutual companies. It is but a matter of justice to the confidential nature of my occupation as an inspector, that this anonymous use of letters has been agreed to by their writers.

The letters from woollen mills will first be read. The proprietor of a fourteen-set woollen mill writes, —

"We have had forty-four Fuller arc lights in operation six months without any repairs. In the weave-room two hundred and eighty kerosene lamps were replaced by eighteen electric lights.

"Electric light costs more than kerosene; but I am quite willing to stand the extra expense, as there is as much improvement in the light as the extra expense would represent. The air is not contaminated, and no overheated rooms, as is the case when using so many kerosene lamps. The help all like them, and their work is more perfect. Our warps are all black: therefore more light is needed than on light work."

The treasurer of another woollen mill using the Brush arc light writes, —

"On account of the flood of light furnished the weavers, thus enabling them to make perfect work, as well as on account of the purity of the atmosphere, we feel that the production is increased to such an extent that we think that we cannot afford to do without it."

The superintendent of a woollen mill manufacturing dark goods, where the Edison incandescent light is used, writes, —

"We find the running cost of the Edison light to be one-fourth that of gasolene vapor, formerly used in our mill. Regarding the advantages of the light, it is better, safer, and cheaper, and devoid of smell or heat."

The president of a woollen mill, a portion of which is lighted with Weston arc lights, writes, —

"The dynamo-machines were put in ten months ago, and have not yet cost us any thing for repairs. We cannot well estimate the actual cost of the light. We have an abundance of power. The cost of carbons thus far has been $3.52 per lamp for ten months.

"It is used in finishing, burling, and repair departments, and is well adapted for our carding and spinning rooms.

"So far as we have had experience with them, we approve of the light."

The manager of a woollen mill formerly lighted by petroleum gas, which has been replaced by Brush arc lights, states, —

"Cost is greater, of course; but we like the light, and don't mind the expense."

It should be added in this connection that these Brush lights furnish much more light than would be possible to obtain from oil-gas.

The superintendent of a woollen mill, where the Edison incandescent light is in use, writes, —

"The light is certainly superior to gas-light, and is much liked by the workmen, particularly the dressers, who require a very good light; and where warps are dressed in different colors it is highly satisfactory in distinguishing the same, which is difficult and sometimes impossible to do by gas-light."

From a few mills on colored cotton goods I select the following. In one mill where the Weston arc light is used, the agent expresses his opinion that —

"The excellence of this electric light consists in its brilliancy, steadiness, and freedom from tendency to vitiate the air. For our particular purpose it also has the advantage of being unaffected by the current of air from the dresser fans."

From a gingham mill lighted by Brush and by Weston arc lights we obtain the following information, —

"We have a thousand looms lighted with fifty lamps, giving ample light, more than we obtained with a gas-jet at each loom. I believe that we could light more than twenty looms to a light; but with these we get a splendid

light, which is the same to us as gas at sixty-five cents per thousand feet. We would not change back to gas."

The manager of a print-works using the Weston arc light states, —

"We have experienced no trouble whatever, and can only speak of the light in its most favorable terms."

The agent of a fine cotton mill, lighted by the Brush arc light, gives this opinion: —

"Our experience leads us to the belief that a system of electricity is to be the artificial light of the future, especially in buildings of any magnitude."

The superintendent of a cotton mill lighted partially by the Maxim incandescent, and partially by the Weston arc lights, sums the result of three years' experience: —

"We have always considered it a success as compared with gas, as being a better and more economical light"

The experience of the manager of a silk mill with the Thomson-Houston arc light leads him to state, —

"We have twenty arc lights over seventy-five looms on silk and tapestry weaving. We consider the light far superior for our purpose to any thing that we have ever used. It is especially useful in distinguishing colors. The power necessary to run the machines has, we think, been underestimated, taking a full horse power to each light. The cost of maintaining the light has been very small; the item of repairs not yet coming in, as none have been necessary. We have an abundance of water power."

The following information is furnished by the officers of two cordage mills: one states, —

"We run four Weston machines of ten arc lights each, making forty lights in all. It requires $32\frac{8}{10}$-horse power to run the whole. The cost of running is about $1.75 per hour: this includes expense of carbons, man's time attending and trimming the lamps, wear and tear, and interest on original plant.

"The lights have been used from one to four hours daily for five months in each of the past two years, without repairs; and we are so well pleased with their working that we are putting them up in our new mill."

Although these lights are reported as perfectly satisfactory, they could not have been regulated to the standard brilliancy. On long circuits, arc lights require about one and a quarter to one and a half horse power each; the power being measured at the cylinder of the engine.

The superintendent of a similar mill, where the Arnoux & Hochhausen arc light has been used for some time, states, —

"We have expended nothing upon them for repairs, with the exception of brushes and other minor articles. I consider the electric light to be far superior to any that I have ever used, in point of brilliancy and steadiness."

The list might be continued to greater length; but enough has been given to show the favorable nature of the experience of the industries represented in this association, with the practical application of the various types of electric lighting apparatus in general use.

Of the arc and incandescent lights, both have zealous advocates. While each has merits which fit it for special work, there is a broad middle ground where both are used with success; and the decision as to their relative merits is indeed a difficult task, and the final result must often be one of personal judgment.

Electric arc lights are used in various large buildings, as founderies, rolling-mills, forges, boiler-shops, and dye-houses, with great success.

In no other place does the arc light show such a marked superiority over other methods of illumination as in these industries. In one instance incandescent lights were unsatisfactory in the erecting department of a large locomotive-shop, while arc lights have been used with success in similar places.

The incandescent light is the better adapted for places where the light must be localized, and would be obstructed by objects which would throw shadows if the light came from some remote source, as is the case of an arc light.

A weave-room two hundred and thirty-five by fifty feet, and ten feet high, contained two hundred and twenty-four yard-wide cotton-flannel looms, which were lighted by a hundred and fifteen gas-burners.

Thirteen Brush arc lights were placed in this room, the light being seven feet from the floor, requiring one light to seventeen looms. Twelve of these identical lamps were removed to another mill in the same yard, and one hung in the engine-room; but the dynamo was not moved, nor its speed changed.

The new weave-room measured two hundred and nineteen by ninety-five feet, and was fifteen feet in height; the light being twelve feet from the floor. Owing to the greater height of the room, these arc lights illuminated three hundred and eighty-four looms, or thirty-two looms to a lamp, in place of seventeen in the former mill.

In the first instance there were nine hundred and four square feet of floor to a light, and in the second seventeen hundred and thirty-four square feet of floor to a light.

This is given as an instance showing how much surrounding conditions have to do in each case. In the first mill incandescent lights would have been cheaper, and in the second this would have been reversed.

Other instances need not be cited, as it is not our object to deal with applications of electric light other than for mills.

SAFEGUARDS OF ELECTRIC LIGHTING.

The experience of the insurance companies in regard to electric lighting has constituted the subject a factor in underwriting. It is difficult to estimate the amount of hazard to which property is subjected by its use, because the elements of danger are diminished by suitable precautions. The hazards attending the use of the electric light have been overestimated; not in numbers or magnitude, but because too little account has been given to the preventable nature of such occurrences. If these precautions are disregarded, only good luck will avert disaster.

It is sometimes assumed by those ignorant of the facts, that electric lighting apparatus cannot set a fire. Electricity is no exception to other forms of energy. All power can be converted into heat. Your mills are equally liable to hot bearings, whether the motive power is derived from the fires under the boilers, or to the head of water in the mill-pond.

Whenever any one states, as a principle, that the electricity used for lighting cannot set fire to any thing, he is not only in error, but is uttering a fallacy which will lead to the destruction of property, if carried into effect in any electric lighting system.

It is better to meet the issue fairly, and the interests of all will be advanced by the consideration of its dangers; for in no other manner can suitable measures for protection be reached.

In the Mill Mutual Insurance Companies there were sixty-one establishments lighted by electricity up to last May.

With few exceptions, the lights had not been in use previous to the autumn of 1881; and many had been started early in the spring.

In these sixty-one establishments I know of twenty-two fires due to electric lighting and assignable to the following causes:

Eight were from globules of melted copper or particles of hot carbon falling out from the bottom of the globes. The actual number of fires from this cause was probably many times this number. That class of fires will not continue to happen, as all makers now set their lamp-globes in a tight stand with a ridge around the edge. A flat plate will not answer the purpose, as there was one instance where drops of melted copper rolled off, and set a fire.

Four fires were due to leaking water or washing floors; and two more were caused by water in a dye-house, condensing on the building to which uninsulated wires were fastened. In most of these instances a grounded circuit formed one of the two connections necessary to divert the electricity from the wires. Many of the lower carbons fell from lamps, and five fires were caused where they fell upon combustible material.

Three fires were caused by cross arcs from one wire to another, where uninsulated wires were fastened against conductors. In one instance the conductor was formed by dust settling upon uninsulated wires; and on a damp day it absorbed enough moisture to form a path for the formation of a cross arc, which started a slight fire.

In another instance the wires were fastened to a damp beam, which was decayed, and was burned nearly in two by the smouldering fire. And in the third instance damp brickwork in a tunnel was a sufficient conductor to establish an arc which did not do any material damage there, but injured the dynamo. Reference has been made to other fires produced by cross arcs started by water, forming a connection between two wires.

In my connection with electric lighting matters for the Boston Fire Underwriters' Union, I know of two fires caused by improper switches; two by water reaching the wires of a circuit already grounded; and one from wires coming in contact with a building, so that their insulation was worn away. There have been many fires from electric apparatus in districts outside of those where I have business, and I do not feel called upon to make any reference to those instances in this connection.

No reference is made to accidents which did not set any fires, although fires would have ensued from many accidents if combustible matter had been present.

I believe that all these fires should be classed as avoidable

fires, because the use of well-known precautions would have anticipated their possibility.

The precautions are known only as a matter of experience, because there was no source of information stating the results from electric lighting currents under certain circumstances.

The damage from these fires was in each instance small, as would be expected. It is the experience of the Boston Manufacturers' Mutual Fire Insurance Company, that in mills three-fourths of the fires are in the daytime, and three-fourths of the losses are in the night: so the chance of loss in the night is nine times as great as in the day. During the last two years the introduction of automatic sprinklers has reduced the damage from night fires one-half.

As the electric lights are used during working-hours, these accidents come under the head of day fires. When they have happened, there has always been a sufficient number of employees engaged on the premises to attend to the matter at once. When electricity is diverted from the system, the lights are correspondingly diminished, and general attention directed to the difficulty.

Eyre M. Shaw, captain of the Metropolitan Fire Brigade of London, when in Boston, during his recent visit to America, stated to me, that, since the introduction of the electric light, there had been about one hundred fires in London from this cause.

Electricity forms the safest method of illumination when the following precautions are observed: The system insulated throughout, so that there is no electrical communication with the earth, or from one part of the apparatus to another, except through the proper conductors, even if the wires should be exposed to water. All switches made with a lapping connection, so that no arc can be formed. Arc lamps provided with globes closed underneath, and the frame so arranged that the lower carbon could not fall out even if the clamp failed to hold it securely.

The wires of incandescent systems provided with a sufficient number of fusible links to secure the system against any damage from an excess of current.

'ing out of these principles in every detail requires
(and constant watchfulness.

Other features in an electric lighting system are advisable to assure the most satisfactory operation of the apparatus and protection to persons, but they may not be essential to secure safety against fire.

The insulation of a system can be assured only by frequent tests. The best instrument for ordinary use is a magneto, which generates an alternating current, and rings a bell like the ordinary telephone "calls." It is used by connecting one wire to the ground and the other to the system. The presence of a fault is indicated by the ringing of the bell when the magneto is put in operation. Means for the systematic trial of the insulation are relatively as important as the use of gauge cocks on boilers.

If an electric lighting system is sufficiently insulated when first arranged, there is no assurance that it will remain so, on account of the numerous changes, blunders, and accidents to which it is subjected. Unfortunately we are not forewarned of any lurking disarrangement of electric apparatus by means of any of the senses, in the same manner that leaking gas appeals to the sense of smell, or as leaking steam produces sound and vapor.

When electric lights become dim in rainy weather, it is conclusive evidence of ground connections, which divert the electricity from the system, causing both commercial loss of electricity and great danger of fire. Two contacts are necessary to divert electricity from an electric lighting system. If one contact already exists, and connects it with the earth, only one more contact is necessary to conduct a portion of the electricity from the system.

In such an event, if the electricity overcomes a conductor of sufficiently high resistance, the electricity is converted into heat sufficient to burn any combustible substance which is present.

Underwriters have two methods of defence against a special hazard, — the one to advance the rate to an amount deemed commensurate with the increased danger; and the other method consists in the removal of the source of danger.

With electric lighting, the hazard, not an inseparable part of the system, can be obviated by the measures which have been referred to, and which are applicable to all systems of electric lighting.

In preparing the regulations for the Fire Underwriters' Union,[1] I did not ask for any precaution not found by the experience of accidents and actual fires to be essential to protect either person or property.

The effects of an electric lighting current upon the person bear no relation to the injury which that current can do to property. Electricity has the two properties of quantity and tension, which are independent of each other. The heating effects are due to the quantity, and the results upon the person are proportional to the tension, of the electricity.

However, the greater the tension, the more liable is the electricity to force its way through bad conductors. The arc light

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[1] REGULATIONS

Of the Boston Fire Underwriters' Union for the Use of Electric Lighting Apparatus.

WIRES. — Conducting wires over buildings must be seven feet above roofs, and also high enough to avoid ladders of the fire department.

Whenever the electric light wires are in proximity to other wires, dead guard wires must be placed so as to prevent any possibility of contact in case of accident to the wires or their supports. Conducting wires must be secured to insulated fastenings, and covered with an insulation which is water-proof on the outside, and not easily worn by abrasion. Whenever wires pass through walls, roofs, floors, or partitions, or there is liability to abrasion, or exposure to rats and mice, the insulation must be protected with lead, rubber, stoneware, or some other satisfactory material. Wires entering buildings must be wrapped so that water cannot enter through the tubes.

For inside use loops of wire must be avoided, and the insulated fastenings arranged to keep the wires free from contact with the building.

Joints in wires to be securely made and wrapped. Soldered joints are desirable, but not essential. Wires conducting electricity for arc lights must not approach each other nearer than one foot; and for incandescent lamps the main wires must not be less than two and a half inches apart.

Care must be taken that the wires are not placed one above another, in such a manner that water could make a cross connection.

A cut-out which can be operated by the firemen or police must be placed in the circuit in a well-protected and accessible place.

LAMPS. — For arc lamps the frames and other exposed parts of the lamps must be insulated from the circuit. Each lamp must be provided with a separate hand switch, and also with an automatic switch which will close the circuit, and put out the light whenever the carbons do not approach each other, or the resistance of the lamp becomes excessive from any cause. The lamps must be provided with some arrangement or device to prevent the lower carbons from falling out, in case the clamp should not hold them securely.

For inside use the light must be surrounded by a globe, which must rest

is produced by a current of high tension and small quantity; the incandescent light is formed by a current of low tension and great quantity.

Therefore, in the arc light system the most secure insulation is essential; but with incandescent lights, if the insulation were ineffective, there would be more liability of fire. In incandescent lighting systems the whole reliance for safety is not placed upon the insulation; but small fusible links are placed at various points in the wires, so that, if the quantity of the current exceeds a certain amount, the fusible link will be melted, and cut off the electricity before other damage could ensue.

Although these safety catches were originally devised for the purpose of protecting the carbon filaments of incandescent lamps from destruction by extra currents, yet they are essential to assure safety against fire; and it is the use of these safety catches, and not from the fact that the electrical portions of

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in a tight stand, so that no particles of melted copper or heated carbon can escape; and, when near combustible material, this globe must be protected by a wire netting. Broken or cracked globes must be replaced immediately. Unless a very high globe is used, which closes in as far as possible at the top, it must be covered by some protector reaching to a safe distance above the light.

For incandescent lamps the conducting wires leading to each building and to each important branch circuit must be provided with an automatic switch or cut-off, or its equivalent, capable of protecting the system from any injury due to an excessive current of electricity.

The small wires leading to each lamp from the main wires must be very thoroughly insulated, and, if separated or broken, no attempt made to join them while the current is in the main wires.

Dynamo-Machines. — Dynamo-machines must be located in dry places, not exposed to flyings or easily combustible material, and insulated upon wood foundations. They must be provided with devices capable of controlling any changes in the quantity of the current; and, if these governors are not automatic, a competent person must be in attendance near the machine whenever it is in operation.

Each machine must be used with complete wire circuit; and connection of wires with pipes, or the use of ground circuits in any other method, is absolutely prohibited.

The whole system must be kept insulated, and tested every day for ground connections, at ample time before lighting to remedy faults of insulation if they are discovered.

Preference is given for switches constructed with a lapping connection, so that no electric arc can be formed at the switch when it is changed; otherwise the stands of switches, where powerful currents are used, must be made of stoneware, glass, slate, or some incombustible substance which will withstand the heat of the arc when the switch is changed.

the system can be handled with impunity, that has given the insurance interest somewhat of a bias in favor of incandescent lighting.

Electric lighting should be encouraged on account of its inherent qualities of safety. Any system that is in conformity to the insurance regulations is also in its best condition electrically.

Electricity, like all forms of energy, is dangerous to the extent that it is not held in control. The same is true of steam in boilers, or water in mill-ponds. Like fire, they are all "good servants, but poor masters."

The PRESIDENT. There are several other gentlemen present who have been invited to address the Association, or to take part in this discussion; and I will call upon them in the order in which their names appear. Mr. Edward Kilburn of New Bedford.

Mr. EDWARD KILBURN. I think, after the exhaustive remarks of Mr. Woodbury, it would be folly for me to attempt to say any thing more than to state that we have just adopted the Edison incandescent system of lighting in our No. 6 mill, Wamsutta Mill, New Bedford, and we have three of the Edison K dynamos, equal to 360 A lights each of sixteen-candle power; and we are running in the mill regularly now seven hundred and twenty lights. On Saturday last we weighed the power required to produce these lights, and we found it to be 83.7-horse power, or 8.6 lights to a horse power; and we light four looms to a light, and so proportionately throughout the mill. The mill has some 51,000 spindles in it; and (we have not had it long enough to determine very definitely about it, but so far as we can see now) we believe it to be as cheap as gas at fifty cents a thousand. We are unable to see it in any other way. I don't know that I have any thing more to say on the subject. Mr. Woodbury has said all that is necessary on the other part, much better than I could. The lights prove with us very satisfactory. It is certainly a beautiful light, and it is free from heat and smoke, etc. Our help like the lights very much indeed, and are very anxious to get from the other mills into this mill, and assign as a reason the electric lights. And we have help come from other mills; and we are overrun with help to-day, and a great many of them assign as a reason

for their coming the electric lights. We run the lights from the engine which drives the mill.

A MEMBER. What is the effect of a slackening of the speed?

Mr. KILBURN. We have seen nothing of that kind so far. Of course, if the speed is slackened, the light would be dimmed; it would be dimmed in proportion to the speed.

Mr. JOHNSTON. Then you require an auxiliary light; that is, have gas in connection with it?

Mr. KILBURN. We have a few gas-lights to light the help out at night, and after the engine stops, and also to light them in, in the morning, before the engine starts; or else we must have a smaller dynamo made. We have gas in the yard, so it is cheaper than putting in a separate engine for it.

Mr. JOHNSTON. Have you had any accidents in your mill from it, or fires?

Mr. KILBURN. No, sir: we have not.

Mr. T. J. BORDEN. What is the speed of the engine from which the power is derived?

Mr. KILBURN. We have a Corliss engine with a thirty-foot balance-wheel which is running fifty-two revolutions, and gives about four thousand five hundred to four thousand six hundred feet a minute.

The PRESIDENT. The next name on my list is Mr. Charles Warren Lippitt of Providence, R.I. If he is present, we shall be glad to hear from him.

Mr. C. W. LIPPITT. Mr. President and gentlemen, I certainly agree with Mr. Kilburn, and commend to the fullest extent the excellent address on electric lighting, which I have had the pleasure of listening to from Mr. Woodbury. I feel there is very little now for me to say. There is one point I would like to refer to before giving some figures, however, which I hope will not be without interest. That is, when I received the notice to appear here to-day in connection with electric lighting, I felt compelled to notify the Secretary, as I admit, that it would be impossible for me to consider the scientific part of this system. My connection with the electric light has been for a year or two only, and that entirely of a commercial or manufacturing nature. The particular matter concerning which I suppose you will expect to hear from me to-day consists of a portion of the experience of the Social Manu-

facturing Company with electric lighting in the Globe Mill, belonging to that corporation, at Woonsocket, R.I. In the fall of 1879, I think, a twenty arc light Brush machine was purchased and put in operation in the mill. It answered the purpose very well, cutting out a large number of lights, and giving satisfaction for a year or two. Since then that machine has been changed; and we are now using two ten-light Weston arc machines. They also have given us good satisfaction. Our experience with the arc light was of such a character that it tended to increase the inclination, felt by several members of the corporation, to try in a cotton manufacturing establishment an incandescent light. Several attempts were made to get a plant of this character; but we were obliged to wait some little time before we could get one which promised to be satisfactory. The machines which we are now using were furnished by the United States Electric Lighting Company of New York. At the time that I applied to them for this plant, about a year ago, they were just on the point of bringing out their present system of electric lighting, and were very much averse to letting me have the machines that we are now using. The reason was that the present system that they are now introducing is far superior to the old system which we have now in use. It was only after a good deal of urging that I obtained permission to put the machines in. It was with the distinct understanding, that, in case at any time any of the results that were obtained from our present plant should be used or published in any way, a careful statement should be made calling attention to the fact that they were old machines, and that they did not produce as good results as can be produced by the new machines. For instance, the most important point perhaps in connection with these machines that we are now using, in which they are inferior to those that are at present being sold, is that it requires one-horse power to produce between three and four lights; whereas the machines that are now being sold will produce from seven to eight lights to a horse power. We have two dynamos, and in connection with them there is a regulator which it is necessary to use with these old machines. The plant, including the cost of the dynamos and the regulators, the foundation, belting, the shafting, the labor necessary to put it up, and every thing complete ready to run, cost $2,552.90. An important part of the expense of running electric lighting

is in the horse power. That I have tried to get at as carefully as possible. The power is taken from the main engine of the mill, that runs about fifty revolutions a minute. It is a double Corliss engine. The expense of the horse power — including interest on the cost of the engine, foundations, the building, the boilers, and so on, taking forty-five thousand dollars to cover those items, also including the coal, the labor, and every other expense that could be fairly charged against the power, whether used for electric lighting or for the production of yarn in the mill — figures down to $\frac{92}{100}$ of a cent per horse power per hour. That is a little over thirty dollars per horse power per year. As this was so near to one cent per hour per horse power, and as that is the ordinary price, I believe, for calculating the power for electric lighting, I have taken in these calculations one cent per horse power per hour as the cost of the power. Following, then, the calculation, I find that eight per cent interest on the electric plant gives me $204.23. It was also found, by carefully testing the engines when they were running the electric lighting machines and nothing else, that they were developing for these two incandescent machines thirty-horse power. Thirty-horse power, at one cent per horse power per hour, figures thirty cents per hour for the horse power. The lights ran during the winter of 1881 and 1882 three hundred and sixty-seven hours. That would give us $110.10 for the cost of the power. The breakage is the next important item. The lights are now guaranteed to burn six hundred hours. Although the lights only ran three hundred and sixty-seven hours, I have taken the actual breakage. Of course that breakage would cost us nothing, but still I have figured it in. The actual breakage of these lights for three hundred and sixty-seven hours was twenty-seven. They were renewed at an expense of fifty cents each, which gives us $13.50 for the breakage. The dynamos and the regulators were taken care of by the engineer who had charge of the main engine, without any extra expense, and consequently nothing is to be charged to the cost of the light for that care. The amount of repairs was practically nothing. After the lights had been running for a few days, some difficulty was found in managing them, and a man came on from New York to remedy the trouble. There was a small bill for his time; but that of course was no part of the repairs, and I have not included it. It was about twenty-

dollars. The total cost of burning one hundred and seventeen incandescent lights for three hundred and sixty-seven hours was $327.83. We burn one light to four looms. That enabled us to cut out two hundred and twenty gas-lights that were called four-feet burners each. Two hundred and twenty gas-lights burning four feet per hour, with gas at $2.20, burning three hundred and sixty-seven hours, cost us $710.60. In estimating the actual cost of the gas, it is necessary to include interest on the piping that is used to carry the gas about the mill, in the same way as we have considered interest on the wires and the dynamos that carry the electricity about the mill. I have allowed six hundred dollars for the cost of the piping, which would be on the basis of thirty-five hundred dollars to pipe the mill carrying twelve hundred ordinary gas-lights, which I understand is a fair estimate for that expense. Eight per cent on this sum gives us forty-eight dollars; making the total cost of the gas that would have been used in place of the electric light $758.60. That makes a saving in the use of the electric light of $430.77, or a percentage of fifty-seven per cent. The result with these old style electric machines, producing only three and a quarter incandescent lights per each horse power, burning them for less than four hundred hours, was an actual saving on the cost of gas of fifty-seven per cent in favor of the electric light.

At one of our other mills we have been using an oil-gas. That of course, as cotton manufacturers understand, is considerably cheaper than coal-gas. I have made some figures in connection with this oil-gas, which, as near as I can ascertain, are accurate. The cost of the oil-gas plant, for a mill using from eleven to twelve hundred burners, is $8,423.29. Estimating the cost of the piping for such a mill at $3,500, it gives us $11,923.29 as the cost of the plant for oil-gas. Interest upon this sum at eight per cent is $953.86. The cost of the oil, labor, running expenses, and every thing connected with the production of the gas for a winter, taking a year in which the cost of oil was, I understand, just about what it is to-day, from eight to eight and one-half cents, the total of all these expenses, including the oil, was $941.01; making a total cost for the oil-gas that season of $1,894.87. The cubic feet of gas produced by this expenditure was 483,900 feet, making a cost per thousand of $3.91. The burners in the mill where this gas is

used for illumination are called one and a half foot burners. If we burn less than that, the figuring would be a little different; but that is practically correct. The cost of two hundred and twenty burners burning one and a half feet of oil-gas per hour, and running for three hundred and sixty-seven hours, is $173.11, against $327.83, the cost of the electric light. The number of burners used with the oil-gas was one burner to two looms. The number of incandescent electric lights was one to four looms; making a saving in favor of the electric light of $145.28, or a percentage of saving over the oil-gas in favor of the electric light of thirty-one per cent. I consider the electric light superior to any other form of illumination, for several reasons. First, on account of the absence of heat. Second, it gives more light for the same money than any other system of lighting. Third, it is fully as safe, if not safer, than any other method of illumination. A very large fire at one of our mills, which caused us a loss of over a hundred thousand dollars, was occasioned by the burning off of a gas-pipe. While there are some dangers connected with electric lighting, they are of a character that can be better guarded against than the dangers connected with any other method of lighting. It is no more than fair to the United States Electric Lighting Company, who furnished these machines to us, that I should call the attention of the Association particularly to the fact that these results, although they are sufficiently favorable to the electric light, have been produced by an apparatus that they were unwilling to dispose of on account of the defects that they knew were inherent in that system. Their present system will produce lights giving twenty-four or twenty-five candle power each, and from seven to eight lights per horse power. These, as you have heard read at the desk, have lasted a very much longer time than six hundred or a thousand hours. As far as the result of our experience with the incandescent electric light is concerned, I can say that it has been so far satisfactory. As far as I know, it is regarded by almost every one connected with the mill as the most superior form of lighting that we have. As an indication of our appreciation of it, we are this year to increase our plant some two hundred per cent; and the new mill that we are building will probably be lighted entirely by the incandescent system of electric lighting.

I feel very sorry, Mr. President, that the time which I pro-

posed to devote to some proper preparation of such remarks as I desired to make here was entirely taken up by an unexpected call in another direction, and I wish to apologize for not being able to present a more extended statement. (Applause.)

The PRESIDENT. I see present here two or three members whom the Board of Government very much desired to hear from on this subject, who did not feel that they could make special preparations for it. I shall therefore take the liberty of calling upon them to give us the result of their conclusions; and I will call upon Col. Thomas Livermore of the Amoskeag Manufacturing Company of Manchester, who has had considerable experience.

Mr. LIVERMORE. Mr. President, since your Secretary asked me to state the facts that have come to my knowledge in the use of electric light, I have endeavored to gather some statistics which we have collected in the use of the arc light in the Amoskeag Mills, which I will give you. We began using the Brush electric light in February, 1880, and have used it ever since. We began using the Weston electric light in February, 1881, and have used it ever since. We are using four hundred and sixty-four arc lights, about half the Brush and half the Weston. We light about five thousand looms with them, besides some carding and spinning. I have fifteen rooms, large rooms, some of them having fifty thousand square feet, with these lights. They are hung, the lights are hung, all the way from eight feet and five inches to ten feet and five inches above the floor, — usually above looms; and those heights, all of them, seem to give satisfactory results. I think in one case there is twelve feet and ten inches, and I think that that height is probably a little better than one lower. During the last eight months, since the position of the lights which we have had in use has been permanently settled, I have had an accurate account kept of the carbons used, and the number of hours that the lamps have burned, also the expenses for carbons, labor, and repairs; and the use of carbons has been about thirty-seven thousand, about equally divided between the Weston and the Brush lamps, and they have burned to that extent that they have furnished one hundred and ninety-eight thousand lamps for one hour. In other words, the number of hours multiplied by the number of lamps gives one hundred and ninety-eight thousand of what we call units of the electric light for the purposes of our

statistics. The total cost for carbons, labor, and repairs, — and in repairs we include brushes, and all those things that are worn out, — has been five thousand seven hundred dollars. That has made an average expense of 2.89 cents per hour for each light. Now, that expense is subject to variation, because we have used some very poor carbons, and also because, I suppose, as the lamp trimmers get more expert, they will trim more lamps for the same wages. The carbons vary as much as oil in their quality. Good carbons ought to furnish light at the rate of one carbon for one lamp seven hours; but I have had them run down to four and one-half. The average of these carbons that I have made this calculation upon was in the Weston lamp 5.14 hours, and the Brush 5.59 hours. Now, to the cost of 2.89 cents per hour per light is to be added the cost of power, the wear and depreciation, and the interest. I do not think that it is safe to say that an electric light can be run without any cost for power excepting the extra coal used; because, while that may do on a small scale, yet I think, as a general rule, you cannot burn the candle at both ends without making it burn faster; and, for every hour that you use the electric light, I think you ought to charge for wages in making power, and for wear and depreciation. The same way I think you ought to charge for wear and depreciation of the electric plant. Supposing that you charge for power, every hour in Manchester, steam power including interest can be made for fifty dollars per horse power per annum. That may be thought large, but it is a safe estimate. That would make a horse power 16.7 cents per day. If you take out interest, it reduces that considerably. Now, whether you run electric light one hour or two hours or six hours in a day, the interest on your plant is running for the whole day, so it is upon the steam plant that you put in to run that electric light; so that if you want to be safe you must charge the interest for the whole day against the electric light, whether you have run it one hour or more hours. Now, taking these figures that I have given, and reckoning the depreciation and wear of the electric light plant on a cost of two hundred dollars a light, — which is a liberal estimate at the present prices that the electric companies charge, — charging interest at six per cent both on that plant and the steam plant, and wear and depreciation at ten per cent, it will make the cost per hour for the arc light 4.8 cents without interest; with interest for one

hour it makes it 10.2 cents. Then for two hours it would be 15.2 cents; half of that for one hour; for three hours, 20.1 cents; four hours, 25 cents; five hours, 30 cents; making the cost diminish very rapidly as you increase in the use. I have compared that with the cost of gas at $1.60 a thousand, which is what we pay in Manchester; and the electric light, supposing that one arc will displace twelve gas-burners, for one hour would cost at that rate for gas, to displace gas, at the rate of $2.04 a thousand; for two hours, at the rate of $1.52 a thousand; for three hours, $1.33⅓; four hours, $1.25; five hours, $1.20 a thousand, — unless I have made a mistake in the figuring; but I have given the items upon which any one can figure for himself. We have colored work, and we have found that one arc light will take the place of twelve gas-burners over looms. We have had one gas-burner over a loom, and one arc light lights twelve looms well; possibly it would light more, but we prefer an abundance of light, because we think there is economy in it, and we have not yet found that we could light, on the average, over twelve looms with one arc light. I have heard it said here, and read in the letters, that an arc light will light, I think, twenty colored looms in some instances; but that is not our experience. If any one undertakes to introduce electric light in the place of gas that he has been using, and expects to realize in the cost of light itself the saving which these figures show, he will be mistaken, because the electric light will be used more than gas is. Our experience is, where a great deal of gas is used in a room, that people hold off as long as they can, because of the heat and of vitiating the air. They have no such scruples with the electric light. Unless people are more watchful than I have been able to be, they will find that the electric light is run more, and therefore the saving will not appear in the balance-sheet as to light; but I am confident it will appear in the quality of the work, and in the quantity of the work. The difference between weaving in summer and winter, of course, is well known; and one of the results of the electric light, I think, will be to reduce that difference very considerably. I have heard it remarked, and have believed, that weaving-rooms which were dark, by reason of being basements, were now considered as good as those above ground, because of the electric light. I know that our weaving has improved both in quality and quantity, but I cannot

attribute it all to the light: I do some; how much I cannot tell, because the causes have so commingled that we have not been able to get the result separate. As to the average number of hours which an electric light will be burned, I find, upon comparing the gas accounts in some fifteen carding and spinning rooms in our mills, that the average during the year for burning gas runs all the way from one hour to three hours; depending upon the situation of the rooms, whether they are dark or light rooms, and what their dimensions are. And I think it may fairly be calculated that any carding and spinning room well constructed and well lighted will during the year average to burn light in all its burners an hour and a half. Now, if power does not cost any thing but for coal, and the electric light will displace twelve or more burners, then it is going to be a good deal cheaper than to use gas at the rate which we can get it. I have had the power required to drive the Weston electric machines tested by dynamometer, and it resulted in showing a little less than ten-horse power for ten lights; but I do not think it is safe to reckon less than ten-horse power for ten lights. I have also compared the power required to run one hundred and twenty Weston lights with one hundred and twenty Brush lights upon forty-light machines, by noting the gate upon the water-wheel which drove them when the wheel drove nothing else, and noting the heights of the water, and there was not enough difference to be worth counting in computing the cost of electric lights; so that I think a horse power per light is what may be safely counted upon to drive either the Brush or Weston arc lights. I have tried two other arc lights, but I don't know the power that they require. They were not satisfactory, and we have not continued the use of them. (Applause.)

The PRESIDENT. The next gentleman I will call upon is Mr. J. S. Ludlam, the agent of the Merrimack Manufacturing Company at Lowell, Mass. He has had considerable experience, and we shall be glad to hear from him. (Applause.)

Mr. LUDLAM. Mr. President and gentlemen, I have had some little experience with electric lights; but it is a subject altogether too new to arrive at any opinions, with regard to results that we may look forward to as really fixed. I have in use at present some arc lamps of the Fuller system, and also some arc lamps of the Weston system. I am using them in

part of my dyehouse, where, owing to the conditions, the rooms are dark, and in some places artificial light of some sort is necessary all the time; and under such circumstances there is no question about the economy of electricity as compared with gas. The subject has been so completely ploughed and harrowed this morning that there remains very little more to say. The fundamental point seems to be, however, the question of interest as divided into the length of time during which the lamp is used; that is, when you come to consider the question of economy. In my place, apart from matters of economy, the light has another advantage with respect to the question of color. I have the light in use in two places, where it is very important that we should be able to distinguish shades of color, and note any variations, and see that every thing is kept to the shade we want; and there, of course, taking that advantage alone into account, the light is very valuable to us. With regard to the question of power, it seems to me that it is perfectly fair to charge electricity with all the power consumed in its manufacture. My business is to make cotton cloth; and, if I have got any power, I can profitably employ it in that way, and I don't see why I should give it to the electrical light people for nothing. I propose to charge them with all the power they get, and, indeed, every thing else. And I have been, I say, unable to make any figures which, with the ordinary use of artificial light in mills, assuming it to be one hour a day, taking gas at $1.60 a thousand as it is furnished to us in Lowell, I have been unable to make any figures which prove to me that there is any very decided economy in the use of electric light. I have also two systems of incandescent lamps in use to a partial extent, — one the Edison, and the other the Maxim so called; that is, the incandescent light furnished by the Weston Company of New England, and which I believe is exactly the same lamp as the United States lamp which Mr. Lippitt has in use. They give very nice lights; and it is only fair to say that with the proposed change which the Edison Company are talking of instituting in my place, that, if they can meet the conditions which they propose to meet, they would be able to beat gas at $1.60. Up to this time I don't think that they have been able to quite do that: it has been touch and go; but, if any thing, the gas has had a little the best of it. The collateral advantages, however, are very great; and what their pecuniary value

is going to be, of course it would take more experience than I have had, or almost any one, in the use of electric lights, to determine. When I say the collateral advantages, I mean the improved quality of the atmosphere, the absence of heat, and I think a decided safety from fire. As Mr. Woodbury has pointed out, electricity is like many other agents that we employ about our mills; and, if we don't take care of it, it will do us a mischief: but I don't see that it is any more dangerous than it is to run steam about in pipes, as we are compelled to do at very high pressures, or acids, as one does about a print-works, all of which, if it was not looked after, would work you a very great damage. I don't think, with an electric plant properly put in in the first place, that there is very much reason for apprehension on the score of danger. I think the first lamp that was put into my mills was put in with uninsulated wires, and it was before the underwriters had tabooed that sort of thing, and we were all very green about it; and the people who put it in — a New York concern — put the plant up in that way, and we ran it for a year or more with perfect success as regards the light. We have since insulated it ourselves by wrapping it with paraffine cloth, and it is running to day the lamps of the Fuller Company. It is a small machine. I put it in my packing-room, where color was also a matter of importance, and I put it in without any regard to the question of economy, but simply to be able to perfectly distinguish colors, and sort goods. I don't think that there are any other points that have been left untouched. Every thing seems to have been so completely exhausted that I will not take any more of your time. (Applause.)

The PRESIDENT. Another gentleman that we desire to hear from is Mr. Charles L. Lovering of Taunton.

Mr. CHARLES L. LOVERING. I do not see that I can add any thing to what has been said. I am using in one room fifty-four Brush arc lights. Each light displaces seventeen and a half burners. I would use in that room nine hundred and forty-eight gas-burners, — a burner to a loom on colored work. I thought up to a year ago, that there was nothing to be saved in the way of expense; but I am rather of the opinion now that there is a saving over gas. I pay for gas $1.75 a thousand, I do not charge against the electric lighting any interest upon the steam plant. Leaving that out, it seems to me, unless I am mistaken, it figures something like a dollar a thousand for gas;

but of course all the interest upon a large steam plant should be charged. I have a surplus of power in that room, and I don't know that I put a shovelful more of coal under the fire: yet I am charging to the electric light account four pounds of coal per horse power for every hour I use it. It is a one-story mill, lighted sufficiently from overhead. The lamps are thirteen feet from the floor, and I get a very perfect light. As has been said by Mr. Kilburn of New Bedford, I am never at a loss to find persons to work in the room: they are always ready to go there. On the floor below, which is only twelve feet high, I am running eighteen lights; and an arc light there will not displace more than twelve gas-burners. But where the room is high, and the rays are thrown so that they will cover more floor surface, an arc light will displace more burners. The space covered by these fifty-four lights is something like fifty-four thousand five hundred feet. (Applause.)

The PRESIDENT. Unless the Association deems it best to pursue the discussion of this subject at this time, — I see the noon hour is approaching, — I think it would be well to take action upon this letter inviting the Association to attend the Fair or Exhibition in a body, where they may see some of the electric lights in use. It has been laid upon the table, and I call attention to it that it may not be lost sight of.

A MEMBER. I would like to inquire if we have an afternoon session.

The PRESIDENT. We usually have one, and I see this call calls for one. It can be omitted by a vote of the Association.

Mr. ATKINSON. Mr. President, may I take but a very few minutes of your time upon the electric light? I think there are two or three points which have not been covered fully, that are of considerable importance from my point of view. It will take me about five minutes to read what I thought was better to put into writing than to trust to merely speaking.

ELECTRIC LIGHTING FOR FACTORIES.

BY EDWARD ATKINSON, ESQ.

It may be expected that I shall have something to say in this debate with respect to electric lighting and its possible dangers; and perhaps you may wish me to add a few words as to its merits.

In making up my own mind as to the policy which the Boston Manufacturers' Mutual Fire Insurance Company and other mutual companies ought to pursue in the matter, I have been obliged, as I have said previously, to study a subject of which even scientific men know little, and of which I knew nothing; treated in technical terms which have themselves been changed by joint consent of electricians during the progress of the investigation. It has therefore been necessary for me to delegate to Mr. Woodbury, who is well prepared by his previous scientific training, the duty of making a complete investigation of the whole subject; and, during the last year, his work has mainly been devoted to the survey and inspection of electric lighting plants in the risks insured by us, including also a full inspection of the different works in which the different kinds of mechanism required are manufactured. In this investigation he has had the hearty co-operation of all the reputable patentees and makers of electric apparatus; and it is a somewhat singular fact, that the rules for the introduction of electric lighting plants, and for their use, which were adopted by the mutual companies with the co-operation of all the reputable electric light companies, have now been standing six months; have been adopted by stock-underwriters, with such modifications as the conditions of miscellaneous hazards require; have been virtually copied by the Society of Telegraph Engineers and Electricians of Great Britain; and have required neither alteration nor substantial addition since they were first issued.

In respect to the mechanism for the development of this force known as electricity, it may be said that the art of generating this power is very old, and that mechanism for this purpose, of

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a very perfect kind, has been long in use in the application of the dynamo-electric machine to electro-plating. There are now a considerable number of dynamo-electro machines; perhaps not as many varieties as there are of turbine water-wheels, but there is substantially the same choice. You can pay a high price for a very perfect machine like the Boyden turbine, from which you may develop ninety or ninety-five per cent of the power applied to its movement; or you may pay a less price for a machine which will give you the equivalent of a turbine water-wheel, rated at seventy-five per cent of the actual weight of water applied.

There are various patents upon different kinds of mechanism used for this purpose; but they are upon mere details, as far as I can learn, and there are as many ways of constructing an efficient dynamo-machine as there have proved to be many ways of constructing effective automatic sprinklers and turbine wheels.

In respect to what is known as the arc system of lighting, it may also be said that the principle of the arc lamp is well understood. The carbon candles are now made substantially pure, and very nearly if not quite homogeneous. There is little to be done in improving the arc lamp, except in the clock-work by which its motions are actuated. The arc lamp is, perhaps, most suitable for use outside the factories, or in large places like dye-houses, iron-works, and rolling-mills; but it is probably not as well adapted to the inside work of the textile factories, as what is called the incandescent lamp.

There are three well-known varieties of so-called incandescent lamps, in each of which a film of carbon is interposed in the current of electricity causing friction or resistance; developing heat in the carbon, and, as the secondary effect, developing more or less light. These films of carbon are enclosed in glass globes from which the air has been substantially exhausted.

The question at issue in deciding upon the respective merits of the Edison, the Maxim, and the Swan light, is, —

1st, The durability of the film of carbon, and its capacity to bear the electric current without being destroyed.

2d, The durability of the lamp as a whole, including the glass globe.

There is probably more room for improvement in the carbons for the incandescent system, or for the substitution of some other

material, and in the making of these lamps, than in any other part of the system of electric lighting. The incandescent lamp may not give as much light in proportion to the power applied, as the arc light will give in certain directions or lines of light: but the incandescent lamp can be placed where the light is most available; and more light can probably be developed of a useful kind, or better adapted to specific purposes, in proportion to the power applied, than from the other system.

As I have said, the whole subject of electric lighting is shingled and plastered over, and obscured by the claims of various patentees; and the relative value or validity of these patents can only be determined when they have been carried through the courts. Every user of every kind of light should secure a sufficient bond of indemnity to protect him against the litigation which has begun, and the possible damage which may ensue. Under what has been called the "*electro-mania*," various substantial corporations and many wildcat companies have been organized; and some of them have been floated at fancy prices for the stock. If it were within the province of an underwriter to issue policies of insurance upon the profits which are expected to be based upon a share in patent rights in electric lighting, I think it would be quite safe to issue policies of a kind once offered to me, when I was the clerk of a manufacturing company, upon a cotton mill, which I submitted to one of the oldest stock-underwriters in State Street for insurance. I unfolded the plans, and described the risk; and he cheered me by saying that he would issue a policy "at a very low rate of premium." As the mutuals had then just begun, and the usual stock rates were very high, I was much encouraged by this remark; and, as I prepared to draw my application, he said, "Perhaps you misunderstand me, Mr. Atkinson: the low rate will be upon a policy assuring you that the mill will be consumed by fire within a reasonable time. We will not insure you against loss by fire at any price."

I think it would be pretty safe to issue policies assuring the large portion of those who take stock in patent rights upon electric lighting, that they will make no profit out of them. The contest will be bitter, but the end is probably not far off when the manufacture of electric apparatus and the use of the electric light will come down to a commercial basis with a fair commercial profit to the best companies making the apparatus,

and a fair commercial profit to those who apply this apparatus to use.

My conclusion individually is this, — that an incandescent light is the true factory light of the future; that it is the safest light which can be put into a mill, the best light to assure perfect work, and the best means of lighting a mill if regard be given to the conditions of health of the operatives. As a mere measure of economy and profit, I have been assured by skilful men who have made use of the electric light in their own factories, that, even if it should cost much more than gas, they would not give it up, because under its use they can secure more and better work from their machinery, owing to the more vigorous condition and vitality of the operatives who attend it.

While I say that I consider the incandescent system the safest, I do not object to the use of the arc lamp under proper safeguards. I consider either system better and safer than gas or oil, if put up properly, and operated under constant supervision subject to the rigid control of a factory yard. It is not to be assumed that there is no danger of fire from the incandescent light; this force called electricity cannot be applied without danger: but all these dangers, as Mr. Woodbury has stated, are of a sort easily avoided, and the dangers from the incandescent system are more surely avoided than the dangers from the arc system of lighting.

In what I have said about danger, you will observe that I limit my observations to the factory yards of which you have charge. The dangers from the rapid extension of electric light wires in cities upon combustible roofs do not rightly come into the present discussion.

I am profoundly convinced, however, that the day is not far distant, when even in our dwelling-houses we shall safely use the electric light and power, and when we shall draw gaseous fuel only from the pipes from which we now obtain our illuminating gas. This is the impression which the developments, now being made in each of these directions, make upon the mind of one who, without scientific training, must yet consider each application of electric science in the conduct of his business.

Mr. JOHNSTON. I would like to ask Mr. Atkinson the question whether the proportion of fires in mills lighted by electri-

city, as reported by Mr. Woodbury, is not in excess of all the other fires in the same mills; and, if so, does that prove that the electric light is so safe?

Mr. ATKINSON. The number of fires under electric plants in mills under our supervision is greater than from any single cause that has ever come under our experience in the same time; but, at the same time, they have led us to the conviction that they are what may be called, relatively, a safe kind of fire. They occur under such conditions and in such places, and are subject to such immediate observation from the effect upon the light, that they have all been put out without loss. The number of fires that occur from other causes of lighting has been very few. There have been not many fires from the use of gas; but there has been very heavy loss from the escape of the gas during fires caused from other sources, and it is on that issue that we look mainly to the safety of the electric light. And, singular to say, although we insure about a hundred and fifty mills which are lighted by kerosene oil, we never yet had cause to pay a loss from the use of kerosene oil *per se*. The only fire that ever occurred from that might have occurred from gas. It occurred from the heating of the metal case of a lantern in a picker-room; and on that metal case the lint rested and caused the fire. So that in this matter statistics we regard almost as worthless, as they often are, unless they are qualified by judgment in the premises. It is our conclusion as to the relative safety as based upon the judgment of all the men connected with the office, and of the most judicious men who are in charge of mills. I don't think there are any statistics that are worth a rap, on either branch of the subject, as to safety. (Applause.)

Mr. C. W. LIPPITT. Mr. President, there is one point which I don't quite understand; and, if possible, I should like to have a little more light upon it. I believe the statement has been made here, that in Manchester, where gas was $1.60 or $1.65 a thousand, it had not been possible, with the modern form of incandescent light, to make a reasonable figuring which would show that the incandescent light would beat the gas. The price that I put upon gas, in the statement that I made a short time since, was $2.20 a thousand, which is the price that is charged in the town of Woonsocket. The figures that I have made, which cover interest on power and the interest on elec-

tric plant, and other expenses of every kind which I could reasonably charge to the cost of the electric light, indicate a saving of fifty-seven per cent over the gas. That would bring gas down to certainly $1.10, and it would indicate a saving of something over gas at $1.65. I hope the gentleman who made the statement that I refer to will give us some of the figures, or some of the grounds, upon which his calculation was made. I should certainly be very much interested in hearing it.

Mr. LUDLAM. I think, in place of Manchester, you should read Lowell, gentlemen. I can give you the figures. I have only three or four minutes at my disposal, and you can do the sum yourself. The incandescent lamps in my case displace two hundred and sixty four-foot burners. Gas is $1.60; you can figure on three hundred and twelve hours a year, which is one hour per day for each working-day. Against that put two Edison dynamos and the same number of lamps, lamps enough to displace each burner; or, in other words, the bill of the Edison Company against me, as it is to-day, is $3,552. On that I propose to figure ten per cent interest and depreciation. I think the Edison Company say that is too much, — that eight is sufficient: eight may be, but I say that we have had so limited an experience with electric light that we don't know whether it is or not, and I want to be safe about it. Take power, twenty-horse power, thirty dollars a year. I will put it cheaper than Mr. Lippitt puts it. It can hardly be furnished in Lowell for that. Thirty dollars a year is a fair price for horse power, where coal is $4.50 a ton. In Lowell it cannot be laid down for any thing like that, and it would be fair to charge more for that, but I can afford to be liberal; I have put it down at thirty dollars a year. Then take lamps on their basis, the life of a lamp to be six hundred hours; and, if any of you can make that figure to beat gas at $1.65 or less, I would like to see the figures. My address is Lowell. Good morning. (Laughter and applause.)

Mr. LIPPITT. I would like to ask the gentleman, before he goes out, if he means one electric light to each gas-burner which burns four or five feet. You say two hundred and sixty gas-burners.

Mr. LUDLAM. Yes, sir: I have got one to each loom, and, by the way, they are eight-candle lights too.

Mr. LIPPITT. I cannot tell how the Edison system would

figure, because I don't know what the cost is, but I know that the Maxim —

Mr. LUDLAM. I have some Maxim also, about which I have not made any figures. They didn't ask me to take it: they were put in on trial as yours were, and they thought they would like to have it in there just to see what it would do; and I am free to say that it has turned out a good deal better than I at one time thought it would. It started up rather unsatisfactorily; but we have re-arranged the speeds, and it is now giving a very satisfactory light. It is a twenty-five candle power lamp. I think that something that is worth investigating, by the way, is the photometric value of these lamps. They have got a very loose way of talking about candle power, these electric light people, that is rather shattering to the nerves of a man who has been getting along with gas; and the way they come in and tell you that they will give you two or three thousand candle power for a horse power is very bewildering. But you have got the figures, gentlemen, and you can work that out to suit yourself. Good morning. (Applause.)

Mr. WEBBER. I would say from my standpoint that I can confirm perfectly the statements which are made in regard to the power to drive the electric lights. I have tried them in a number of places, and I spent three weeks some three years ago in testing the power employed to drive the Fuller electric lights in New York. I took the measurements with a photometer, and I measured the amount of power required. I got various results from seventy-five candles up to two hundred per horse power. I gave them to the Fuller Electric Company, and they were so much disappointed that they declined making any public notice of them. At that time the Brush and one or two others were claiming two thousand candle power per horse power. When the Fuller found they could only get two hundred, they would not publish it. But subsequent results have proved that my tests taken then were correct, of two hundred candle power per horse power; and I have tested several times the Brush and Weston machines, getting about the same results of one-horse power to each arc burner, which I have verified, and verified the results which I made in New York, and got the exact candle power given.

Mr. GARSED. As this is our hour for adjournment, I propose that the thanks of the Association be extended to Mr. Wood-

bury for his very elaborate and exhaustive paper on the subject of electric lighting. (Adopted.)

The PRESIDENT. The Secretary will please read the invitation to attend the exhibition again, as many members are now present who were not here when it was first read.

(The Secretary read the invitation.)

Mr. ATKINSON. I move that we dispense with the afternoon session, and go to the Fair an hour after adjournment, taking the hour for lunch in the usual way.

(An amendment was offered, to go to the Fair at half-past two o'clock; which was accepted, and the motion was adopted.)

Mr. GARSED. I think it is but fitting that this Association should take some notice of the death of Gov. Straw, our first President; and I therefore move you that the condolence of this Association be tendered to his family, and that proper resolutions be drawn with that view. We all know his services in the early history of the Association, and his gentlemanly deportment to us all. I do not think the opportunity should pass without an expression of this Association of his worth.

The PRESIDENT. How do you propose to have the resolution drawn, sir?

Mr. GARSED. I think the resolution should be drawn, of the condolence of this Association with his family, unless somebody makes a better suggestion.

The PRESIDENT. Do you move to appoint a committee to draught a resolution?

Mr. GARSED. Yes, sir; and that the President and Secretary be authorized to do so. (Adopted.)

Subsequently the following resolution was adopted as draughted by the committee: —

Resolved, That the death of the Hon. E. A. Straw, the President of this Association from its origin in 1865 until his voluntary retirement in 1878, calls for an expression of our profound regret. His early, constant, and active efforts to advance its interests contributed most effectively to its success; and we place on record this tribute of our sincere esteem for his ability in his profession, his integrity and strength of character, and his hearty manliness in social intercourse.

Resolved, That we tender to his surviving family our respectful sympathy in their bereavement.

Mr. ATKINSON. I would like to give notice that we have had one or two fires recently from the combustion of steam-

pipe covering; and it is our intention to have a series of exhaustive experiments tried upon the non-conducting properties of the various steam-pipe coverings which are offered. They will be conducted here under the charge of Professors Whitaker and Ordway, both with reference to their non-conducting properties and their safety; and I ask suggestions from any member upon the subject. There is very little positive knowledge, apparently, about it.

The PRESIDENT. I would like to call the attention of the Association, before it adjourns, to a request made by a very feeble gentleman named Mr. William B. Earle, who claims that he has invented a machine for the setting of card clothing, by which the amount of work done upon the card can be increased a hundred per cent. I know nothing about it except his statement. He asks that a committee be appointed by this Association to investigate and see what he has done.

Mr. GOULDING. Have you any evidence that he is not insane?

The PRESIDENT. I don't know any thing about it, sir. He belongs to the Earle family of Worcester. I promised to bring the matter to the attention of the Association, and I have done so. My mission is ended unless the Association should take some action in the matter.

Mr. C. I. BARKER. If a committee was appointed as called for in that notice, and they should report favorably, machine-shops might lose business. Mr. Lockwood is suggesting already that we do away with one-half of our cards: hence I should say it would be well, if the man has got such a thing, to come here and show it.

The PRESIDENT. He has not that right. He asked for permission to address the Association to-day, and I told him that I could not grant it to him, but if he would wait here the matter could be decided by the Association; but he declined to wait.

Mr. HENRY LIPPITT. I move that Mr. Thomas Pray, jun., the editor of "The Boston Journal of Commerce," be appointed a committee of one to inquire into the merits of the invention. (Adopted.)

Mr. GOULDING. I move that the thanks of the Association be tendered to Mr. Harris for the exhibition of his spindle and ring. I think it deserves more attention than we have given to it; and I think, if we go in a body to the Manufacturers' Insti-

tute, that that will be one of the things which we ought to look at. It is in the line which we ought to investigate. I move that the thanks of the Association be tendered to Mr. Harris for his paper on the subject of spinning. (Adopted.)

On motion of Mr. Garsed, the meeting adjourned.